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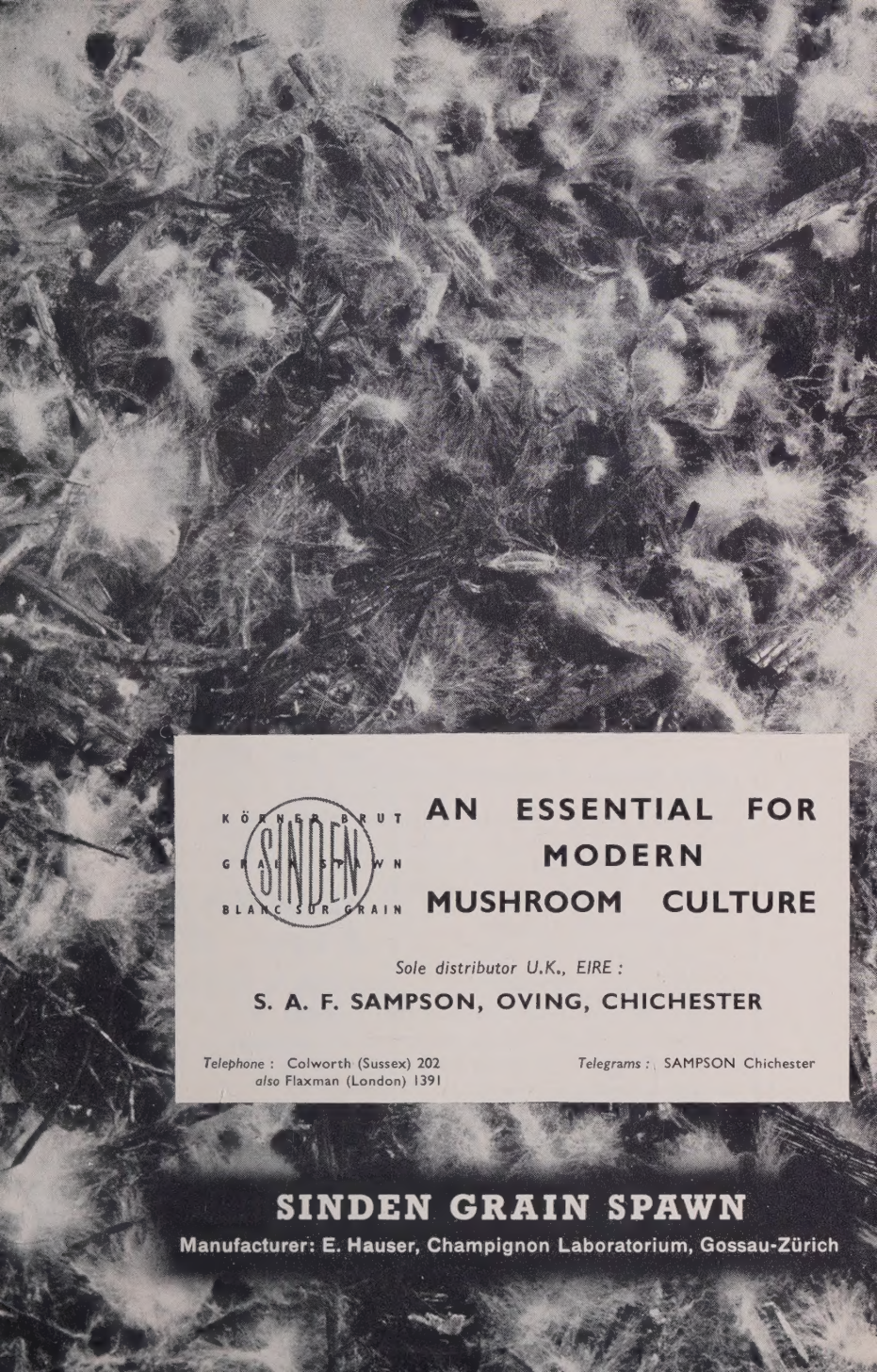

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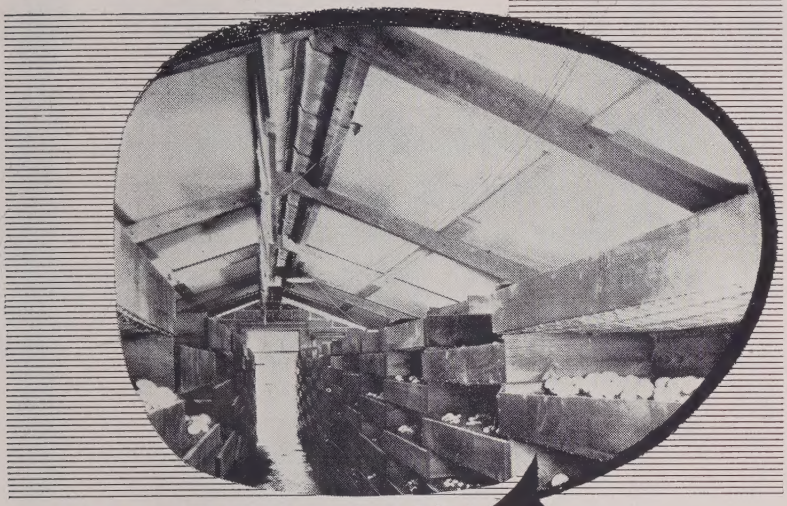

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AUGUST 1952
NUMBER 32

HEATING SYSTEMS

A Survey *by* HARRY DAWSON

The writer of these introductory notes claims no expert knowledge of either mushrooms or heating, but has a general and enquiring interest in both.

To talk about alternative methods of heating for a particular mushroom farm is one thing : to talk about them for the industry in general is something very different and much more difficult.

The inherent advantages and disadvantages of each method can be sorted out fairly clearly. But as the final answer for the individual grower is his crop and the average annual return it brings, any general survey of heating systems is somewhat hogtied by the impressive assortment of variations and complications to be found in the industry at large. However, we press on.

To begin, we are faced with these basic facts : (i) neither fuel nor labour is any longer plentiful or cheap and these costs are representing an increasing percentage of total outgoings ; (ii) the mushroom crop is sensitive to comparatively small changes of temperature ; (iii) improved growing techniques are calling for a more flexible use of heat and for more precise control of temperature.

The initial cost of a heating system is not now the governing factor. A heating system must be capable of economising both fuel and labour as well as meeting the finicky requirements of cultivation. So heating efficiency and operating economy must now be more carefully weighed against initial cost and probable cost of maintenance. And, let us mention, it is more than ever necessary to make cost comparisons on a basis of accurate measurement as well as common sense. (The article by Dr. Edwards in the June " Bulletin " shows the right way to set about it.)

For the supply of heat there is a choice of three main sources :

(i) Hot water,
(ii) Steam,
(iii) Electricity,

with sometimes a combination of two of them or even all three.

HOT WATER

In a hot-water heating system the supply may come direct from a hot-water boiler, or from a calorifier in which the water is heated by steam from a separate boiler.

The water can flow round the system either by the leisurely natural gravity circulation (utilising the difference in weight between the hot flow water and the cooler return water), or by accelerated circulation (utilising a pump) which pushes the water round faster or farther.

In either case the water, having given up some of its heat to the system, returns to the source to be heated up again.

The heating circuit can be continuous piping round the house or it can be piping plus panels (the " panels " may be grids or coils of the pipes, or cast iron plates backed with small waterways in the form of ribs, spaced at intervals in the pipe run).

A common cause of poor and patchy heating which should be stressed, because it is all too often neglected or overlooked, is the presence of air in the system. The best modern practice is not to rely on somebody remembering to open the air cocks now and then, but to fit small automatic air eliminators at the high points of the system.

With a low-pressure hot-water heating system a separate boiler is needed for steam sterilisation and peak heating.

STEAM

When steam is the chosen heating medium, the boiler (or boilers) supplying the house heating will serve also for sterilising and peak heating.

Steam is generated at low pressure and enters the system at 5 lb., 8 lb., 10 lb., or 15 lb. per sq. in., according to the particular installation, and sometimes as low as 1 lb. or 2 lb. pressure. From the standpoint of economy, the lower the permissible pressure the better.

As it passes round the system the steam gives up its readily-usable heat (called the Latent Heat) and, in so doing, returns to the water state. This water of condensation is, of course, still hot (as hot as the steam) and if left in the system would continue to give up heat. But it would part with heat far less effectively than does the steam and to leave the water in the system would merely reduce the overall heating efficiency. So this condensate is discharged through steam traps (devices which let out the water without letting live steam escape), but is not allowed to run to waste. As it may still be at a temperature of 212 or 210° F. at the point of discharge, the condensate is piped back to the boiler-feed tank for re-use in the boiler in place of cold make-up.

Heating efficiency depends to a considerable extent on the correct steam-trapping installation, which is able to discharge air freely as well as water, and economy depends on a proper condensate return for boiler feed.

The heating circuit can be continuous piping, or piping plus "panels" or grids or coils, or piping plus unit heaters (about which more will be said later).

ELECTRICITY

Present conditions of supply seem to rule out electricity for house heating, largely on account of cost, but the method must be included in this general survey. [*And see Mr. Canham's article.—Editor*].

As a heating medium, electricity is clean and handy, easy to control, easy on labour, and easy on space. That much must be accepted. But it seems generally agreed that until there is a tariff of something less than ½d. a unit, electricity cannot compete on running cost with other forms of heating. And for some winters yet we must in any case expect power cuts.

Until electricity becomes a practicable proposition for house heating its present possibilities seem to be confined to short-time sterilising or supplementary heating.

Tubular heaters or industrial-type unit heaters would be used for heating circuits or as supplementary heaters. Plate-type resistance heaters are generally provided for sterilising and wire grids under and through the beds are a possibility for pasteurising.

POINTS FOR DISCUSSION

It isn't intended that the articles in this Heating Number should be one-way traffic. We all have much to learn about controlled heating and ventilation and it will be of the greatest benefit, not only to the industry as a whole but to each individual grower, if everybody will weigh in with their comments and views.

As in almost every other aspect of mushroom growing, heating methods and techniques are still a subject of argument and the " Bulletin " is a good place to carry on the discussion between meetings.

This Heating Number isn't intended merely as a catalogue of alternative methods, but as an opportunity for members to sort out some of the controversial points and get the whole thing on some sensible footing. So *your* ideas and suggestions and criticisms will be very welcome.

To start the ball rolling here, very briefly, are a few main points for discussion :

1. For the highest efficiency (which means a maximum average return from a minimum average cost) it is clear that there must be, basically, a proper co-ordination of heat-using operations, in sterilising, pasteurising and growing. That is entirely possible, and certainly sensible, when starting from scratch with a new farm, and still possible (though less easy) when adapting or extending an existing system.

2. Peak heating (or pasteurising or sweating out), where it can be adopted, is regarded as one of the biggest advances towards increased production. Generally, the method employed is governed by the facilities available. But does the importance of peak heating suggest that it should be a major factor in deciding the type of house heating system ? If so, and if co-ordinated heating operations are accepted also as the thing to aim at, does this mean that all future development will tend to be in the direction of low-pressure steam ?

3. More attention is being given to air movement in houses—for example, in reducing the temperature difference between top and bottom beds during peak heating, and in correcting indoor conditions during periods when outdoor temperature tends to be higher than the temperature inside the house. Doesn't that tie up with the form of heating system ? Unit heaters, as readers will know, are heating coils (steam or hot-water or electricity) backed by a fan that blows air through the coils, the warm air flow being directed where you want it by louvres. To what extent can we consider a unit heater system for this double purpose : to provide heat (when it is needed) and a reasonably-controlled air circulation ; and when heat isn't needed, to provide the air circulation only ?

4. That might lead us to go a step farther and consider a simple form of air conditioning ; a heater battery (a larger and modified form of unit heater) connected by ducting, with air outlets at strategic points of the house. Enclosed in the ducting at the downstream side of the

heater would be jets to spray water into the warm air stream. This arrangement could provide (*a*) dry heat and air circulation, (*b*) heat with moisture added according to humidity requirements, plus air circulation, and (*c*) air circulation alone. The variations in conditions would be automatically or semi-automatically controlled. Has such an arrangement been tried ? And what are members' views on it ?

5. Coming back to the point about the difference in temperature between top and bottom beds. Isn't there here a case for considering the merits or otherwise of " radiant heating " ; that is, piping (steam or hot-water) arranged as grids embedded in the concrete floor of the house ?

6. Another matter, of increasing significance, is thermostatic control. Whilst it is not new to the mushroom industry there is much scope for developing its use. It can be applied to any of the systems of heating mentioned in this survey. A point to remember is that there are several forms of thermostatic control, some complicated and expensive and others comparatively simple and correspondingly cheaper. Besides the motorised valve types, of which members will have read, there are self-operating and direct-acting instruments, needing no electricity or any other kind of auxiliary power, for controlling the temperature of both steam and hot-water systems. There are also thermostatic three-way diversion valves for hot-water systems that control the temperature by automatically varying a mixture of the hot flow and the return flow. A new type of three-way diversion valve now being introduced in buildings, in other industries, on accelerated hot-water heating systems, has a master thermostat located outside the building which gives automatic regulation of the temperature of the heating system *in advance* of the effect indoors of outside temperature changes. There is no way of knowing, without trying it out, just how effective this type of controller might be for our purpose. It is mentioned here as a further indication of the scope for investigation in the application of thermostatic control.

A final point, before we go on to the specialist articles on the various heating systems. Efficiency and economy are governed not only by the method of heating but by the correct choice and correct installation of the equipment. *The best results are possible only when there is close collaboration between the grower, who knows precisely what he is after, and a heating engineer or contractor who is equally expert at his job.*

FUEL EFFICIENCIES

A most interesting table has been shown us by a heating engineer and we pass it on for members to study . . . .

1¼ tons of coal, hand fired (with an efficiency of 54·5%), is equal to :

1 ton of coal, automatically fired (68%), or 140 gallons of oil (75%), or 250 therms of gas (76%), or 9,000 KWH of electricity (92%).

To relate these figures to the cost of the various fuels produces some enlightening answers.

ELECTRICAL SPACE HEATING

By **A. E. CANHAM**

The use of electricity for space heating in the horticultural industry is generally dismissed as being too expensive to merit serious consideration. While this is undoubtedly true of tomato growing in large glasshouses using present techniques, there are exceptions to this rule and mushroom houses offer a combination of conditions which are more favourable to this type of heating.

One of the important aspects of indoor mushroom culture is the need for an air temperature which is constant, which is uniform over the house and which can be adjusted as required between spawning and the first appearance of the mushrooms. This need can be filled admirably with suitable electrical space heating methods. An adjustable thermostat gives close temperature control which may be varied at will and uniform heating can readily be achieved by suitable positioning of the heaters.

The very nature of a mushroom house in which light is only required for functional operations and may readily be supplied artificially enables a well insulated building to be used. This cuts down heat losses to a minimum and therefore enables electricity to be used much more economically than in glasshouses, and at the same time helps to keep the temperature distribution uniform.

Mains voltage tubular heaters are a popular form of heater but have certain disadvantages for horticultural work and especially for mushroom culture due to their comparatively low surface area and high surface temperature. To be satisfactory for mushroom growing the source of heat should have as large a surface area as possible and this should be at a comparatively low temperature to reduce drying of the air to a minimum. A loading of 60 watts/ft. run of tube is the standard for tubular heaters, and if a lower loading could be employed they would no doubt be more satisfactory.

An alternative system has been introduced in recent years which is essentially a modification of the low-voltage soil warming equipment. This is known as the low-voltage conduit system and consists of long lengths of heavy gauge screwed steel conduit of $\frac{3}{4}''$ diameter through which current is passed at a low voltage. This conduit can be mounted uniformly over a mushroom house and the transformer fixed either just inside or just outside. The whole equipment should be controlled by a rod type thermostat and contactor which will give a temperature control within $\pm$ 1° F. These thermostats are adjustable so that variations in temperature can be made as required.

It is very robust and perfectly safe as only voltages below 30 are employed, and has the advantage of a larger surface area for a given loading, and therefore a lower surface temperature, than tubular heaters.

As with any electrical heating system it is quite automatic and its running cost is only that of the current consumed. Once installed its existence can be almost forgotten except for temperature adjustments as required. Practically no maintenance is required, no labour charges are involved and there are no fuel storage, stoking or ash handling problems.

One installation of a type similar to this provides heat for a 3,000 cu. ft. mushroom house on a commercial holding in Berkshire, and was described by the grower at a Conference in Reading in December, 1950. The beds are in tiers of three each side of the centre path and provide a growing area of 450 square feet. Running costs were quoted at an average of 2s. 6d. per 24 hours. He also said that the temperature distribution was very good and that he had found no drying effects. In short, he was quite satisfied with the suitability and economy of his installation and after several seasons use he still considers it to be the best heating system for this purpose.

Any mushroom grower interested in the advantages of electric heating would do well to consider the further advantages that the low voltage system has to offer. Electrical heating is no longer synonymous with localised heating and in this form it has no greater drying effect than hot water or low pressure steam pipes.

Growers who are interested in this equipment should consult their Electricity Board who will be able to supply them with detailed information on the subject.

ATMOSPHERIC CONTROL

By **C. V. WARD**

Managing Director, Atmospheric Control Ltd.

The reliable and close control of conditions obtainable by central station air-conditioning plant is too well known to necessitate my elaborating upon it, were it not for the physical limitations of mushroom houses and the excessive capital expenditure rendering such an installation an uneconomical propostion.

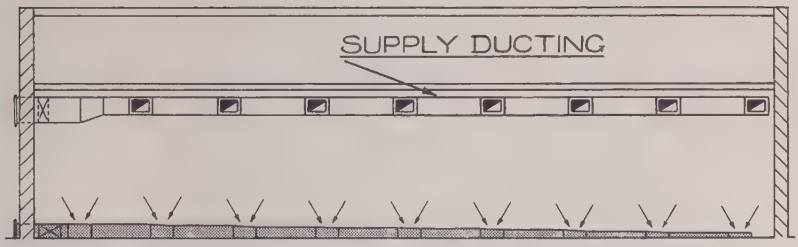
Nevertheless, it is true to say that some considerable measure of improvement and control of conditions can be obtained for a reasonable expenditure if the problem is approached with an intimate knowledge of the physical limitations involved.

With these factors constantly predominating our approach to the problem we endeavoured, and we believe succeeded, to establish a principle whereby temperatures of about 60° F. could be obtained in a mushroom house when outside temperatures in the region of 80° F. were prevailing.

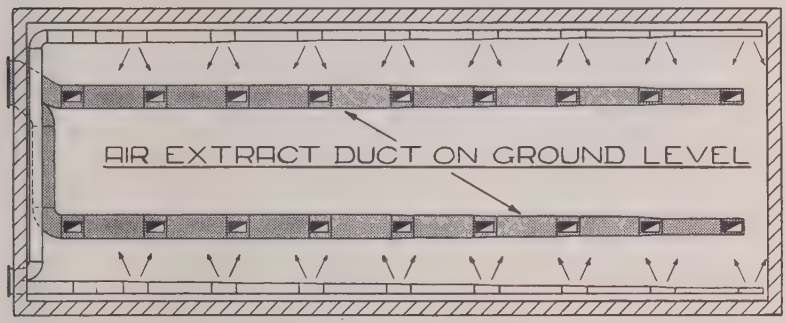
We proposed the employment of a portable air-conditioning unit operating on the principle of extracting the air from any one house, passing it through a spray of deep well or mains water, and then returning it cooled to the house by gentle diffusion. In this way, many of the difficulties confronting growers when they have to wait until propitious natural conditions prevail would be eradicated.

Even houses having little insulation could be kept at 60° F. when the outside temperature was 80° F. by employing mains water at 49·5° F., which is a very safe figure to assume. Deep well water is likely to be at a lower temperature.

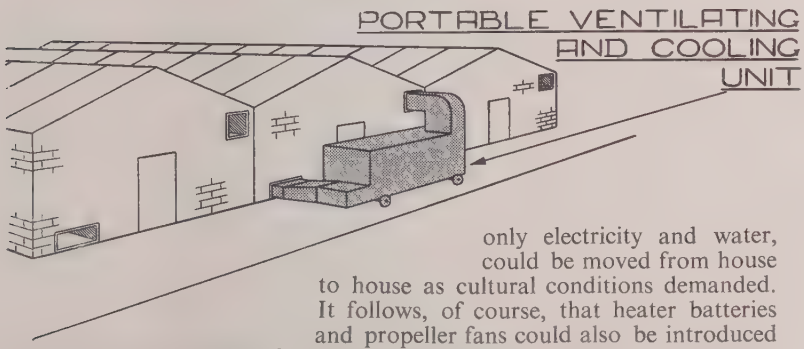
It will be seen from the illustration that ducting could be snugly accommodated at both high and low levels. It is designed in such a manner as to obviate draughts on the beds. This ducting could be installed in each growing house, while the unit itself, which requires



SECTIONAL ELEVATION



PLAN



only electricity and water, could be moved from house to house as cultural conditions demanded. It follows, of course, that heater batteries and propeller fans could also be introduced to the ducting system for use in cold weather, providing an excellent heating and/or ventilating system.

It will be recalled that Mr. Middlebrook in the April Bulletin stated that one of the soundest maxims in the whole of mushroom growing was " If in doubt—ventilate."

The writer trusts that the foregoing will awaken interest in this very serious problem of overcoming the stagnation which often prevails in mushroom houses, particularly at the moment of coming into crop.

RADIANT HEAT

By **FRERE ALLNUTT, of Mount Spawn Laboratories**

This type of heating consists of bedding the heating pipes in the concrete floor, thus warming the entire concrete. It has been used for heating dwelling houses in American and other countries (in some cases the pipes being built into the walls) and it has also been adapted for heating brooder houses for rearing chickens in this country.

Advantages are :—

1. Heat is distributed evenly throughout the floor.
2. Ventilation is uniform right down to floor level.
3. There are no pipes above floor level to take up space.

These advantages make it particularly suitable for the Tray System of mushroom growing.

The method which we have used is to lay $1\frac{1}{2}''$ galvanized pipes 1′ apart over the entire floor level and then put down 3 to 4 inches of concrete over all, so that the top of the pipe is about 1″ below the surface of the fresh concrete. This would be the method to be adopted with a new floor but, in the case of existing concrete floors, the pipes could be laid on the surface and then $2\frac{1}{2}''$ of concrete could be added. We have connected these pipes to some 4″ iron heating pipes, which were already heating another range of buildings.

There are two methods in which these pipes can be laid. One is in the form of a " coil " or continuous line of pipe and the other is in the form of a " grid " where the cross pipes are joined with each of two end pipes. We have only used the " coil " system as the " grid " appeared to be more likely to produce air locks.

Great care should be taken with the laying of the pipes, as there should be a very slight steady rise up to the far end of the house, with a subsequent fall back to the boiler. Water will circulate sufficiently well if this rise is constant. If there is any slight levelling or fall, the circulation will be too sluggish.

When we first tried this form of heating, we found that the circulation was very sluggish indeed and we installed an electric booster. This produced an excellent circulation but we were convinced that this booster should not be necessary. On checking our levels, we found two places where there was an extremely slight fall instead of a rise, and these were found definitely to be checking the flow but, when relaid correctly, allowed the water to circulate without the need for the booster.

It should be borne in mind that we have only used this type of heating in two small experimental growing houses with a total capacity of 3,000 cu. ft. It is quite satisfactory on this small scale, although we find that the great length of pipe does tend to cool the water down and the floor near the pipe exit is not so hot as it is near the pipe inlet. It is possible that this could be remedied by a slightly greater rise and fall but probably the best solution would be a small electric booster, which would ensure a satisfactory circulation. These are very economical to run. It is possible that the " grid " method of laying pipes would be more satisfactory but we have not yet tried this.

AIR CONDITIONING

By **E. J. BATTEN**

Air conditioning, although referred to at times as a new industry, has been an established branch of engineering for forty years. At first, the control of atmospheric conditions was applied principally to industrial processes in which temperature and humidity played a dominant role in the manufacturing of products where the natural climatic conditions did not provide optimum production conditions.

Air conditioning is defined as the treatment of air to produce, under control, specified conditions of :—1. Temperature ; 2. Humidity ; 3. Air Motion ; 4. Air Purity.

The intricacies of this mechanical process were known to the writer before the phases of :—1. Peak Heat ; 2. Spawning ; 3. Casing ; 4. Growing ; as applied to the mushroom industry.

By further enquiry and reference into the growth of the mushroom outside its natural habitat the problem resolved itself as follows : It is to simulate, over an extended period, the ideal atmospheric conditions obtaining during the limited natural growing period of the true *Psalliota campestris.*

These conditions, made known through the research of the field biologist, are, as we all know, difficult to pin down. There is no certainty of finding mushrooms in a meadow on any dewy morning. There are also some queries, the answers to which affect the application of air conditioning to commercial production. For instance, " Is it necessary to reproduce the natural range of air or ground temperature over any favourable 24 hours, which is presumably a contributory factor in the growth of the field mushroom "? Research could probably provide the answer.

Now to translate the phases of the grower's cycle into sets of conditions. Although they vary in some degree with different authority they can be summarised within reasonable limits. They are :—

1. **Peak Heating.** Maximum temperature of 140° F. in a sealed chamber with maximum humidity, the natural compost heat to be boosted artificially if required to attain this figure. This is, of course, not a natural condition but one of proven value as the last phase in the preparation of the growing medium, assisting as it does the biological change and destroying " bugs ". The virtue of having static air conditions in the shed during this operation or circulating in a closed circuit is problematical but it is considered that circulating air may produce more even quality in all beds and may conceivably be used as a vehicle for the fumigant.

2. **Spawning.** With beds at 70° F. and relative humidity of 75%—85%. (By the way, relative humidity is the percentage of water vapour in the air at a given temperature compared with saturated air at the same temperature). Once again air circulation providing even conditions without draughts should be an advantage whilst the mycelium is running.

3. **Casing.** Temperature of beds reduced to 60° F. following casing with relative humidity maintained at 75%—85%.

4. **Growing Period.** Optional temperature 50—60° F. with desired humidity, say 75%. The bed temperatures can be regulated to retard "flushing" or hasten a crop, dependent on the market requirements. Ventilation is effected by the introduction of outside air with the re-circulated air of the shed. This intake can be regulated to give the requisite number of changes of atmosphere per hour—two are suggested with consequent dilution of carbon dioxide content, particularly at floor level.

These, then, are the grower's requirements passed to the engineer for action.

The mushroom house to be air conditioned remains basically of the design of the accepted house in use to-day. It is a well insulated building, capable of being made air tight.

The equipment is manufactured in a compact, self-contained form.

The five ton unit—tons of refrigeration, not weight—is the capacity most likely to suit a large house. The refrigeration is of the direct expansion type with a motor driven compressor for the refrigerant gas, "Freon" or methyl chloride. The machine room would be placed conveniently against the end wall of a long house. Air is drawn from the house through a grille at floor level and mixed with a proportion of outside air. It is then heated or cooled as required to a temperature set by the thermostat control. The electric heating element would be used as a booster to room conditions for peak heat. Humidity is supplied by passing the air through a chamber with sprayers supplying the water as a mist across the path of the air. Once again a humidistat controls the humidity by regulating the flow of water. This also washes the air. Air filters exclude airborne "bugs", etc.

The conditioned air is then distributed throughout the house by means of a blower and ducting designed and arranged to give the required amount evenly and without draughts. This circulation is possible on a closed circuit, i.e., by-passing the air conditioner. With favourable ambient conditions a large proportion of outside air can be circulated with purification and humidification only.

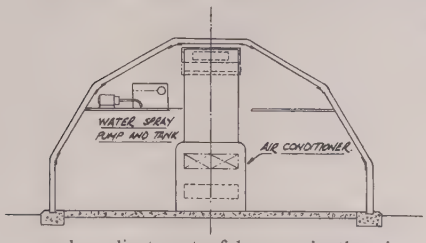
So, accepting the compost prepared to the grower's satisfaction as the best growing medium, the engineer can take over from the point of a house with filled beds. Each set of conditions can be reproduced with narrow margins by a few adjustments easily managed by the grower-cum-engineer.

So much for the engineer's solution of the grower's problems. But the grower's obvious reflection is "What would be the operational cost with falling market prices for the mushrooms?" Air conditioning as an aid to mushroom growing is an accepted method abroad where there are extremes of climatic conditions not experienced in our temperate zone. It is only fair to state that the writer's experience was gained in Malaya.

Ambient conditions in Singapore of 86° F. and 70% relative humidity persist through the year and it would be impossible to grow the English strain of mushroom without air conditioning. With these conditions as a datum it was a comparatively easy matter to provide the necessary conditions. The cooling side of the equipment was needed continuously

but a well insulated house resulted in considerable economy in the actual power used. Thus, a small experimental house proved a profitable venture since the market was excellent. Composting for the first time in tropical conditions without expert advice and purely on text book knowledge, a crop of 320 lb. was raised on 250 sq. ft. With a first rate compost it is felt that this would have been exceeded. It is interesting to note that "competitors", human and biological, were not encountered during these experiments. At home the main job of the conditioner would

AIR CONDITIONING APPLIED TO A STANDARD MUSHROOM HOUSE



FEATURES:

Temperature. Controlled by thermostatic switch operating refrigeration or heating.

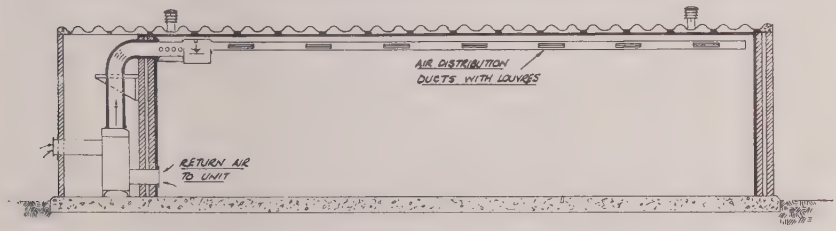
Humidity. Controlled by humidistatic switch, operating spray pump. Tank fitted with immersion heater.

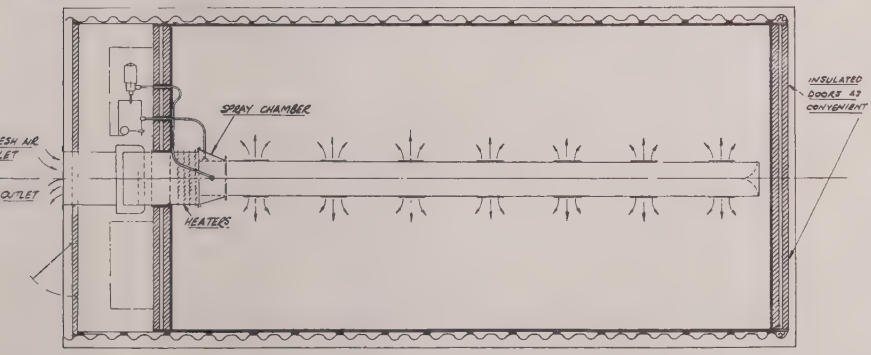
Ventilation. Any mixture of air, fresh and re-circulated, and reasonable changes per hour, can be achieved by adjustment of louvres in the air conditioner.

Peak Heating. Heaters on, and outside air excluded, with air in the house under circulation.

Fumigation. BHC generators introduced in the air distribution ducts, and gas evenly spread under re-circulation conditions.

Existing ventilators to be kept closed, except perhaps when clearing the house.





be to supply heated air except during the occasional summer conditions and periods when outside conditions closely approached those required in the house.

The capacity and therefore cost of the equipment depends on the houses to be conditioned, their volumetric capacity, orientation, insulation, etc., and each would require individual assessment for capacity of plant, installation, running costs, etc.

The illustration shows a typical layout of air conditioning applied to a standard " Handcraft " Hut of 5,000 cu. ft. capacity (36 ft. × 18 ft.). Any increase in the insulation provided for normal growing will reduce both the initial cost of equipment and subsequent running costs. Doors should be well insulated. To economise in the cost of heating the air changes per hour would be reduced to a minimum consistent with a healthy production. It is considered that two heaters would be sufficient to maintain an equable growing temperature if infiltration was minimised.

Its appeal lies in the cleanliness of operation and nicety of control—the ability to apply and maintain a set of conditions as easily as on a wireless set.

It is understood that new strains of mushroom spawn have been produced on the continent which are prolific when grown under definite conditions of temperature and humidity. It appears that they are the result of research into the fact that certain types of mushroom grow better in defined areas of the caves dependent on proximity or otherwise to the entrance. If such claims for the spawn are substantiated it is not idle to suggest that the selection of a spawn with definite characteristics, and growth in a house with conditions " on tap " to suit, can reduce mushrooms growing to an exact science.

First Equipment and Running Costs

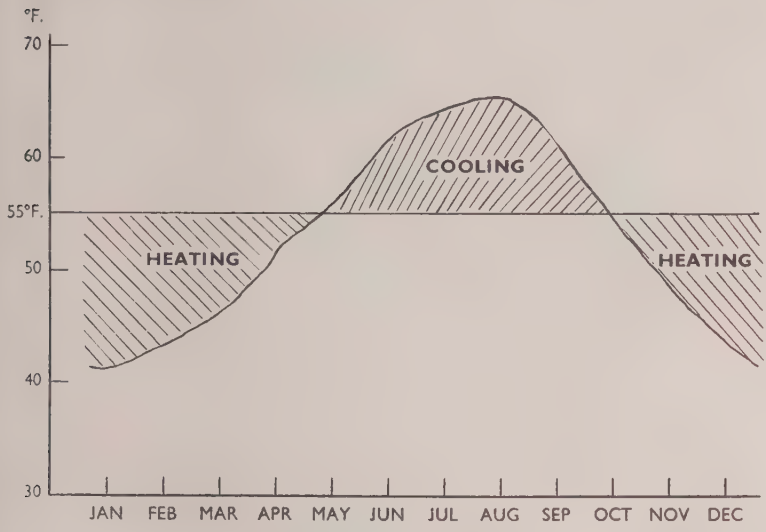
The air conditioner has a limited use in this country and is manufactured mainly for export. Probably for this reason it has been impossible to get firm prices for suitable conditioners for home use. One quotation of £275 could conceivably be reduced when trade discount, etc., were applied.

Basing an estimate on this figure, however, as the worst case the installation would cost approximately £400. This includes for the extension of the house, all accessories, fabrication of ducting and installation charges.

The ventilation fan in the conditioner would be running continuously to effect requisite air changes per hour. Refrigeration would be applied for the summer peak, and heating as required for the remainder. An average annual cost would be in the region of £6 per month. This includes for the intermittent operation of the spray pump and immersion heater.

Operating costs are based on a typical curve of ambient temperatures throughout the year—including a summer ! (The figures for the average outside temperatures in London over the past seven years for each of the calendar months were supplied to us by Messrs. Negretti & Zambra Ltd., of Regent Street, London. EDITOR.)

On a brighter note as far as costs are concerned it is known that air conditioners of a suitable type occasionally become available from Government disposals. Such a purchase could easily reduce first equipment charges by, say $33\frac{1}{3}\%$.



LOW PRESSURE STEAM HEATING

By **C. H. FAWCETT, A.M.I.E.E.**
Director, Burgess & Co. (Engineers) Ltd.

There has been a rapid growth in the number of low pressure steam heating installations for mushroom houses in the last three years and a description of the system with its various advantages may prove helpful to those growers who have no personal experience of its use.

A central boilerhouse is employed for raising steam and the position of this house need not be fixed to the lowest point of the mushroom houses as with hot water. Its site can be selected to suit the grower's own wishes, the most suitable position for fuel delivery, fuel storage or any other factor of economic importance on the particular nursery. In general, the position chosen is as near to the centre of the blocks of mushroom houses as the road facilities and buildings permit. In any case the boilerhouse will be above ground level and there will be no problems of lifting clinker and ashes from pits, or flooding of stokeholes in wet weather. A single boilerhouse with either one or two boilers will serve any area of mushroom houses.

The steam mains, unlike those of hot water, can transmit steam over quite long distances and can be raised or lowered for road crossings, etc., as found desirable. Heat insulation is more important than with

a hot water installation and the use of effective lagging adds no small expense to the initial cost of the plant, but the saving in running costs is proportionately high.

Small diameter steel heating lines are employed and these give 6″ more growing space or pathroom in the mushroom houses than would be available with 4″ cast iron pipes. In most installations thermostatic control is applied to the heating lines in the growing (and the pasteurising) houses. By this means artificial overheating is avoided, with a resultant saving in fuel and better growth of the crops. The humidity of the houses can readily be increased by fitting steam "bleeders" to the heating lines. Complete isolation of the heating can be achieved for any house being emptied and cleaned. The efficacy of the sterilisation process for the house, before a new crop is commenced, can be increased by direct steam injection into the house at the time of applying formaldehyde.

Peak heat can be obtained either in the pasteurising houses or in a growing house by means of direct steam injection into the house, by the use of a large amount of fixed heating pipe (in the case of a permanent pasteurising house) or alternatively by temporarily introducing gilled pipe with flexible end connections. This gilled piping can be moved from house to house as required.

Many growers find it necessary or desirable to sterilise their casing soil and this process can be carried out readily and economically by means of steam injected by a John Innes type fixed grid or by Hoddesdon pipe. The wide range of tests carried out by the various Horticultural Research Stations during the last two seasons have proved beyond question both the efficiency and the economy of sterilising soil by low pressure steam. In the event of the grower having glasshouses in addition to mushroom houses, there will be facilities available to him for sterilising potting soils, pots, canes, etc., at any time the heating installation is in operation, by simply opening a steam valve.

Despite the advantages referred to above, most growers will still be largely concerned with the economics of installation and running costs. It can be stated with confidence that all of the installations that have been carried out by my company have running costs appreciably lower than any normal hot water installation of similar size. This economy results in part from the use of a boiler having an unusually high efficiency and in part from the use of forced draught equipment or automatic stoking equipment. The former enables low grade, and hence comparatively inexpensive, fuels to be burnt effectively. The latter, although requiring a somewhat more expensive fuel, will burn this fuel more efficiently and will show a considerable saving in running cost over a hand-fired boiler burning coke or anthracite.

So far as installation costs are concerned, it is unfortunately true that for very small installations, low pressure steam heating equipment will be more expensive than a similar sized hot water plant. This arises from the extra cost of the high efficiency steam boiler, its control and safety equipment, and quite expensive heating insulation. On larger mushroom units, as with larger glasshouse units, low pressure steam should cost no more and may well cost less than an orthodox hot water

installation. The increasing use of the system indicates that the installation cost is not an obstacle to its adoption.

A word of warning is perhaps not out of place in conclusion. Low pressure steam is not inherently more economic than hot water. The economic running costs that have contributed so largely to its popularity in the past result only from careful design and the correct choice and application of materials. Again, safety of the plant for unattended duty at night is not inherent ; it is due to the use of adequate multi-stage safety devices. *Be careful to obtain sound advice from heating engineers with experience in this branch of horticultural work.*

HOT WATER HEATING

By **J. LINDSAY KINNELL, A.C.G.I., B.Sc., A.M.I.Mech.E.**

The provision of a simple, but easily controlled, heating installation for mushroom production presents difficulties not encountered with glasshouse heating.

The principle of construction of glasshouses shows little variation and only the main dimensions alter. The mushroom house, on the other hand, can be a simple shed of no known ancestry to a specialised building of modern construction and of high insulation value. For glasshouse heating, therefore, a standardised installation can be employed, but, for mushroom production, each installation must be designed as an individual plant.

The modern method of mushroom production requires an installation to give much greater range of temperature than formerly, with a definite high peak temperature for a short period and preferably with some form of automatic temperature control. Future installations will, no doubt, require more elaborate and close control of humidity and ventilation.

The curve shown in Figure 1 clearly indicates the " peak," and has been drawn to show the generally accepted ideal temperature-time curve for a complete production cycle.

Obviously, it would be uneconomical to size the main heating installation to give the 140° F. temperature, which is required for a few days only, against possible outside temperature of 32° F. However well the mushroom house is designed and insulated a proportion of the heat required is lost, not by transmission through the building, but by necessary ventilation and humidity control. To maintain a 130° F. at least $2\frac{1}{2}$ times the heating surface to maintain 75° F. would be required, with corresponding increase in boiler size and capital outlay.

It is accepted practice, therefore, to design the installation to give a temperature of 75° to 80° F., and to obtain the peak temperature by means of an additional heat source, such as steam jets from a portable sterilizing boiler, portable stoves or even electric heaters.

In view of the various types of buildings used as mushroom houses, it is recommended that the plans be carefully surveyed by a competent engineer, who would be able to calculate with accuracy the heat lost from the building and determine the amount of heating surface required, and boiler power necessary.

The installation itself may be low pressure hot water, high or low pressure steam, electricity or gas, or simply slow combustion stoves. This article will deal mainly with heating by low pressure hot water which still remains the most popular type of heating of all types of buildings in this country, since the low temperature heating surface has been found to be the most suitable form of radiation for our climate.

Low Pressure Hot Water Heating

The *advantages* of heating by low pressure hot water installation are :—

1. It is reliable and simple and can be maintained and repaired by unskilled labour.
2. The temperature of the heating surface can be varied over a wide range and it is capable of great overloads in the case of sudden very low outside temperatures occurring.
3. It can be constructed throughout of cast-iron which has the greatest resistance to corrosion of all metals commonly used. The installation, therefore, has long life under the damp and adverse conditions obtaining in mushroom houses.

The efficiency compares favourably with other systems and, *correctly designed*, will give overall efficiencies of 60% to 70%. It can readily be adapted to mechanical firing, either by stokers, forced draught units, or oil burners, where efficiencies up to 80% can be obtained.

The main *disadvantages* of such a system are :—

1. The pipe heating surface is necessarily large compared with high temperature surfaces such as are used with steam and, therefore, the installation takes up more growing space.
2. Owing to the large volume of water used, control is not so rapid.
3. Steam is not available for sterilizing, or injecting into the houses for humidity purposes.

As a guide to indicate the amount of heating surface needed, a block of specially constructed houses of high insulation value, each 75′ 0″ long × 20′ 0″ wide, requires approximately 180′ 0″ of 4″ piping in the form of a single loop with an additional row in the outside house to maintain 70° F. to 75° F. The type of heating surface recommended is a large diameter plain hot water piping ; gilled tubes can be employed, but they are difficult to keep clean and the efficiency falls off in time, due to corrosion and clogging of the gills. If small bore gilled tube is employed, an electrically driven circulator is necessary to provide even distribution.

Circulators

The installation of a hot water circulator, with low pressure heating installations, is recommended. A modern circulator is highly efficient and consumes only a very small amount of power. It promotes a rapid circulation, so that there is negligible difference between flow and return, giving even distribution of heat throughout the houses, irrespective of boiler temperature. The flow of water through the boiler is also more rapid, assisting the transfer of heat from the fuel to the water, with a consequent fuel saving.

Automatic Control

Automatic control of air temperature can easily be obtained with a hot water installation, although a full description of various ways and means is beyond the scope of this brief article.

Briefly, temperature control can be by thermostat acting on the automatic stoker, oil burners or other automatic firing equipment. This is the simplest method of applying automatic control.

With hand fired installations the problem is not so simple. There are various ways in which automatic control can be obtained. In one, a damper regulator is arranged to maintain a constant water temperature, and the heat to the various circuits is controlled by motorized valves and air thermostats. In another arrangement small electric motors controlled by thermostat operate the dampers of the boiler directly ; with this the circulator can also be started and stopped according to the heating load.

Future Developments

The writer is of the opinion that future development in heating will include humidity and ventilation control. In other words, *the future ideal plant will be a complete air conditioning system giving a controlled atmosphere and ventilation rate.* The capital cost of such an installation is necessarily high and, at the present time, it is uneconomical. It must be remembered that reliability to a great extent means simplicity, and the simpler plant with less refinement of control is the best proposition for the grower of mushrooms with a medium sized mushroom farm.

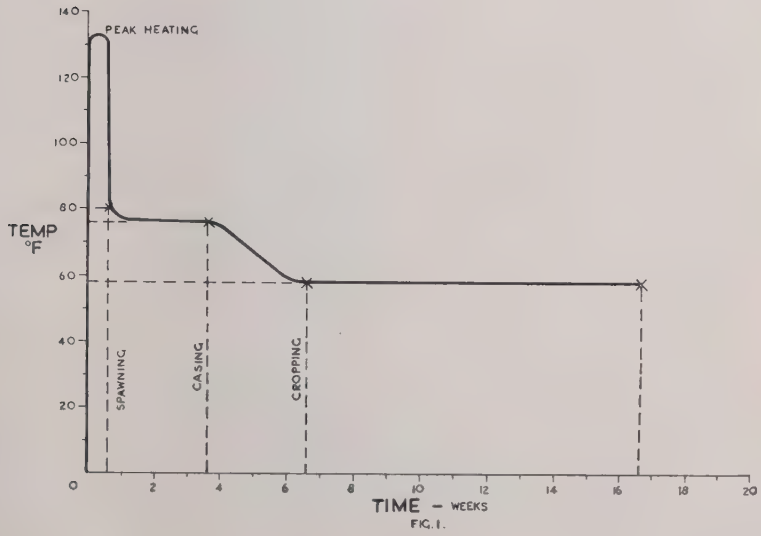


FIG. 1.

FARM WALK IN EAST SUSSEX

The Walk at Mr. T. Dowmunt's Holly Grove Mushroom Farm, Newick, on 5th July, started at three o'clock. The party did not break up until 10.30 p.m. The writer of this note finished up at midnight inspecting another grower's bed (mushroom bed) in the process of being cased, and rounded off the day with an excellent meal of bacon and eggs. (*What, no mushrooms ?—Editor.*)

About 40 members, wives and foremen attended, including Mr. J. Stewart-Wood, M.G.A. Chairman ; Mr. Harold Boxall, Chairman-elect ; and three other members of the Executive. A most interesting tour of this up-to-date shelf-bed farm occupied most of the afternoon. Growers saw modern mushroom houses where insulation and ventilation had been carefully considered. A drum-type soil-breaking machine and the new cold storage plant caused interesting debates.

Eventually the party was enticed away to the Bull Inn, Newick, for tea, where Mr. Stewart-Wood moved a vote of thanks to Mr. Dowmunt. In the open discussion which followed, Mr. Stewart-Wood emphasised the value of friendships created and the other benefits derived from Area Meetings, and Mr. Boxall asked for opinions on the present fixed subscription rates as opposed to a sliding scale geared to cropping area. Trays *versus* Shelves was a favourite topic as usual.

The arrangements for the Walk were made by the Kent, Surrey and East Sussex Area Committee.

(*The photograph was taken for us by M.G.A. member R. W. Jennings*)

Reading Show : Mushrooms were well represented in all the competitive displays of produce at the " Britain Can Grow it " Show at Reading in June. Canga Mushrooms Ltd., members of the M.G.A., showed mushrooms growing in trays, and had an excellent display of M.G.A. literature. On the Ministry of Agriculture's grading stand Mr. Angus Watson displayed mushrooms in their recommended grades alongside specimens which should be excluded.

Congratulations : We congratulate M. de Roselle, Hon. Treasurer of the French Mushroom Growers' Federation, who was recently created Chevalier, and M. Dekeirel, Administrative Secretary, who was created Officier of the French Order of Merit for Agriculture. M. Dekeirel is well-known as a visitor to England.

New Members : The following joined the M.G.A. in June : Lt.-Col. W. Avenour, Hom Lodge, Hom Green, Ross-on-Wye, Herefordshire ; M. de Winter, 13 Wapenhoogestraat, Berchem-Anvers, Belgium ; *M. Lacey*, Gellibrands, Arborfield, Berks. Changes of address are reported by W. V. Bateman, Parkwell Nurseries, Wellsbridge, Nr. Bristol, Glos. ; and Dr. D. L. Piette, 21 Montague Road, Richmond, Surrey.

Research Fund : Contributions received in June totalled £123 15s. 0d., bringing the Fund to £1,296 8s. 8d. The contributors were **Geo. Monro Ltd.,** £25 ; **Mrs. E. Hauser** (Switzerland) £20 ; J. S. Soutter £10 10s. 0d., J. Dowmunt, L. F. Lambert (U.S.A.) and A. Stuart, £10 ; C. & J. R. Webster and J. Wood & Sons Ltd., £5 5s. 0d. ; W. Knight & Sons Ltd., and B. Pratten, £5 ; J. E. R. Simons Ltd., £4 4s. 0d. ; A. Huggins and Lady Townshend, £3 3s. 0d. ; Miss S. A. Miller, £2 2s. 0d. ; Brigadier J. S. Nichols, £2 2s. 0d. (second contribution) ; S. Cwynar, £2 ; and K. C. Bradley £1 1s. 0d.

Visits to my Farm by established growers I do not mind, day or night ; but in future prospective newcomers who have got my name from the Association will only be welcomed provided two conditions are fulfilled : (1) I have had previous notification from the M.G.A. of their names and addresses and when they intend arriving ; and (2) They are *bona fide* and not just inquisitive bodies.

People just take it for granted that they can walk into a small man's place as mine is, discuss disease, abnormalities, soils, etc., in complete harmony with the unfortunate and harassed owner and grower ; but (a) they can't (b) I won't !

We have nothing to hide, and I genuinely like to help if I can, as I was helped by others. But I don't have magnificent foremen or secretaries here and, in common with some other small growers, fail to see (a) why the M.G.A. should be set upon in this way, and/or (b) why the M.G.A. should set upon us to show all and sundry round without at least two or three day's warning. Surely common courtesy demands this ?

Capt. GILES TWEEDIE.

The Secretary wishes it to be known that he never advises anyone to visit grower-members of the M.G.A. without an appointment. It would be a salutary lesson to some intending growers who consider our purpose in life is to help lame dogs over stiles, at the expense of our own businesses, if we all made it a principle not to show visitors around without a prior appointment.—*Editor.*

Stanley Middlebrook's Diary

June 14th. In support of all our theories about the desirability of adequate air movement, the coming of the cooler weather—especially at nights—has meant a return to normal cropping. Hot, stuffy, muggy, windless outside conditions are our worst enemy. They prevent pinheading.

June 18th. Prices have fallen much earlier this year than last. It looks as though we may now regard the period April to September as a potential annual red light. Prices down to 2/- (in a few cases) are below cost. I foresee a time—nearly upon us—when expansion will have to halt. This will apply to big growers ; small growers may be in worse case. Paradoxically, now is the time to spend more and more on research to cheapen cost per lb. by producing more lbs. per sq. ft. Few of our costs can be cut much, so the only answer is more production for the same cost. But HOW ?

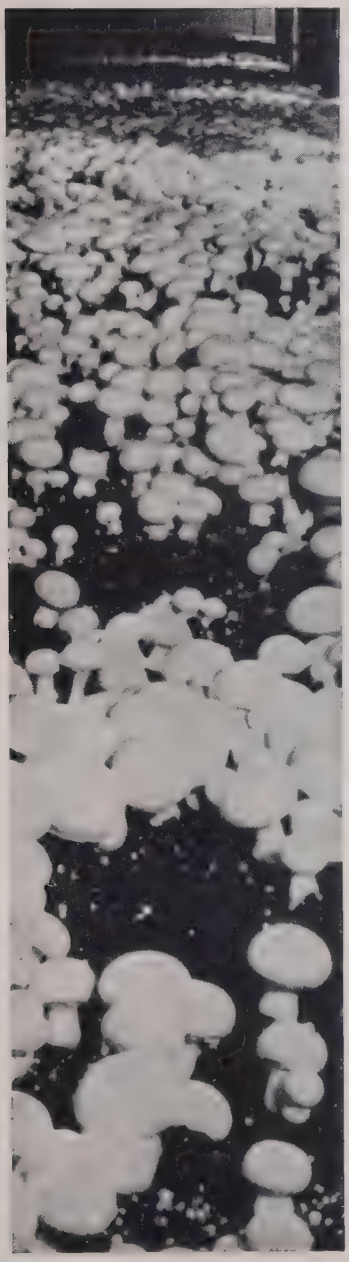
June 21st. White Plaster is increasing rapidly here. Why is it mainly on trays ? I think tray growing is a potential source of danger. We can grow everything (except mushrooms) better on trays than on shelves.

June 23rd. Doubting my ability to write a full page, and yours to see what you're looking at, the Editor asks me to use my space to tell you that all the articles in this issue except the last three pages of gossip are concerned with the heating of mushroom houses. (It seems my page is hot air too !) Heating, he would persuade us, is an important subject and he feels that a presentation of arguments for and against the more useful forms of heating might be most helpful if appearing simultaneously. (How right he is, for once !) Further, I am to suggest that readers might care to give the Editorial Board their views on this issue and the " simultaneous presentation " idea. Please send constructive opinions to the Editor and derogatory, defamatory, slanderous or abusive observations to me—I need a few basic thoughts for the September Diary !

June 25th. Some disagreement among housewives about the value of maintaining size during frying by previously dipping in boiling water. Three ladies, at least, say that while size is maintained all taste is lost.

June 26th. Said one highly efficient tray grower to his foreman (who had just tried to show him some diseased mushrooms from a growing room), " Don't waste my time with those things ; I'm not interested. Take 'em away. Our job is to grow mushrooms, not disease."

June 30th. Extract from a friend on holiday in Rome : " I have investigated the possibilities of growing mushrooms here and find that I can start a farm using Calceo-seaweed sprayed with Methylamino Benzoate-p-Dimethylethyl Carburol. This produces a flush of 8 lb. per sq. ft. in 5 days. I am therefore offering you a half share in this farm for 4,500,000,000 lire (4½d). The ultra violet is filtered out by a mist of . . . (*illegible*) . . . oxide and the mushrooms come up inside out. But a reversing machine can be bought for 5,000,000,000 lire (5d) which reverses them for sale. Wire acceptance." I wired : " It all depends on *which* oxide."



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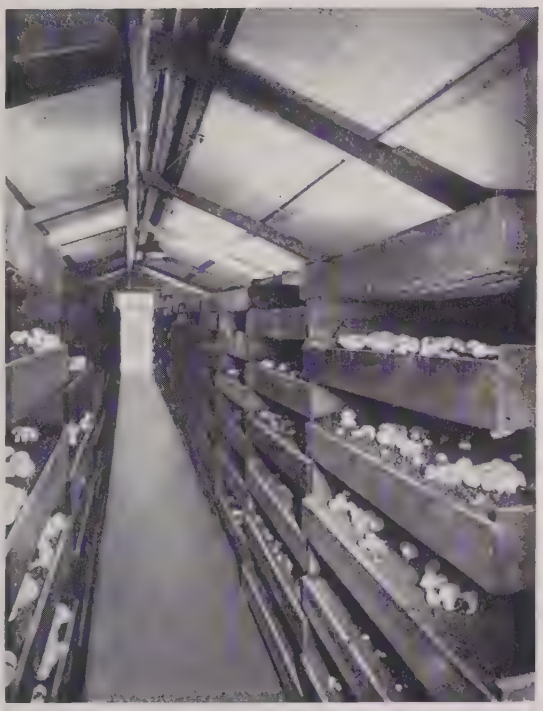

Inside a typical KING Prefabricated Mushroom House, one of a number designed, manufactured and erected by Geo. W. King Ltd. for Dr. A. R. Rooke, Alton, Hants.

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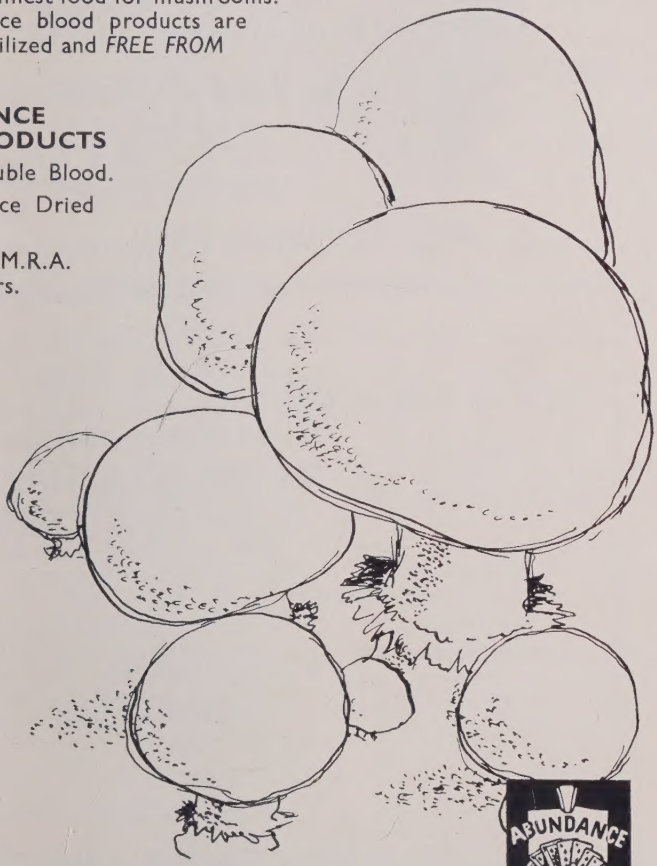

write for details and prices :

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● COMPOST FOR MUSHROOMS

WHEAT STRAW when treated with ADCO "M" will readily provide a substitute for horse manure for growing mushrooms

ADCO "M"

IMPROVES MANURE SUPPLIES

● LONG STRAW MANURE

Manure for mushroom culture such as that from racing stables is frequently in too long and dry a condition. This can be considerably improved by using ADCO "M" with better crops as a result.

Particulars & Prices from **ADCO LTD.** HARPENDEN, HERTS

MURTHANE

Murphy-Zinc-Ethylene-Bis-Dithiocarbamate (Zineb) formulated as:

To Control
MYCOGONE
DACTYLIUM
VERTICILLIUM
RED
GEOTRICHUM

FOR MUSHROOM GROWERS

● MURTHANE WETTABLE

Use 1 lb. per 100 gallons, applied at 1 gallon per 100 sq. ft. of bed.

1 cwt.	£97 10 0
56 lbs.	£50 0 0
28 lbs.	£26 0 0
14 lbs.	£13 10 0
7 lbs.	£7 0 0

Wet spraying costs approximately 2/- per 1,000 sq. ft.

● MURTHANE DUST 15%

Give three applications at 8-12 oz. per 1,000 sq. ft. of bed or apply weekly at 4 oz.

1 cwt. @ 4/6 lb.	£25 4 0
56 lbs. @ 4/9 lb.	£13 6 0
28 lbs. @ 5/0 lb.	£7 0 0
14 lbs. @ 5/3 lb.	£3 13 6
7 lbs. @ 5/6 lb.	£1 18 6

Dusting costs approximately 1/1 per 1,000 sq. ft.

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WHEATHAMPSTEAD HERTFORDSHIRE

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ANNOUNCEMENT : To save confusion in the trade, Reuben C. Darlington (late of W. Darlington & Sons Ltd.) wishes it known to Old and New Clients that he has no further connections with the firm of W. Darlington & Sons Ltd. whatsoever, and that he is at present trading as R. C. DARLINGTON (Mushroom Spawn and Insecticides Specialist), Hastingwood, Harlow, Essex. 'Phone : POTTER STREET 138 (where trade inquiries would be welcomed).

THE SEVENTH

Annual Mushroom Lunch

will be held at the

CONNAUGHT ROOMS, LONDON

On Wednesday, 1st October, 1952

at midday

THE GUEST OF HONOUR WILL BE

MR. JOHN HENSLEY

Head of the Horticulture Division
of the Ministry of Agriculture

THE ANNUAL GENERAL MEETING WILL FOLLOW

AT 2 P.M.

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